# NASA ADVISORY COUNCIL MEETING

**April 16, 2009**
**NASA Headquarters**
**Washington, D.C.**

# Meeting Minutes

Marguerite Broadwell
Executive Director

Kenneth M. Ford
Chair

# Table of Contents



All committee presentations can be found on the website http://www.nasa.gov/offices/nac/meetings/09-04_presentations.html

# Advisory Council Meeting
NASA Headquarters
Washington, D.C.
April 16, 2009

## Introductory Remarks

Dr. Kenneth Ford, Chairman, welcomed everyone to the second NASA Advisory Council meeting of this calendar year. He noted that the council had just completed two days of productive fact-finding meetings in preparation for today's meeting. He reminded everyone that this is an open public meeting held in accordance with the Federal Advisory Committee Act. After all the presentations and deliberations take place, the public attendees will be asked to share any comments they might want to make. Marguerite Broadwell, Executive Director, announced that the NAC website has been improved and can be accessed at www.nasa.gov/nac. The presentations from the meeting will be posted on the website. Dr. Ford commended Ms. Broadwell on her good work on enhancing the website.

## Science Committee

Dr. Jack Burns noted that nine science missions in the next year will be in the process of launch or are going to be undertaking major activities. These include the astrophysics missions: Herschel, HST SM-4, Planck, and SISE; Earth science missions: GOES-O and Glory; the heliophysics mission: SDO; and the planetary science missions: LRO/CROSS and Messenger Flyby.

***Astrophysics Exoplanet Exploration***
Dr. Michael Turner reminded everyone that this is the 400th anniversary of Galileo turning the telescope on the sky. Since that event, we have increased our ability to see fine details in astronomical objects (called resolution) by a factor of 10,000. This is also the International Year of Astronomy during which NASA will be participating in many of the events.

A first slide showed the Galaxy Triplet, which is spectacular to the eye and shows three glowing galaxies. Dr. Turner pointed out that the three galaxies (Arp 274) are, in actuality, quite a distance from one another. In a competition to celebrate the International Year of Astronomy, the public picked this target, imaged by the Hubble Space Telescope, as the contest winner.

The next slide showed what happens when two galaxies are close together. The Hubble advanced camera for surveys caught two galaxies "colliding," which Dr. Turner said was a misnomer since they actually pass through one another. The large gravitational forces cause interesting results. One can see the two galaxies ripping each other apart—which triggers star formations. Most galaxies have undergone a collision.

Another set of images that NASA released as part of the International Year of Astronomy is the M 101 galaxy, a face-on spiral galaxy about 22 million light years away in the constellation of Ursa Major, similar to the Milky way, but larger. Three separate images combine data from NASA's Chandra X-Ray Observatory, the Hubble Space Telescope, and the Spitzer Space Telescope. The three images include the optical image from Hubble (where you see the stars), the Spitzer infrared image (where you can see the dust glowing in the infrared), and the Chandra image (where you see the hot gas). The images are combined for a larger picture with the three images superimposed into one. This image was distributed to more than 100 planetariums, museums, nature centers, and schools across the country in conjunction with Galileo's birthday on February 15. The public's attention has also been captured by the Hubble servicing

mission. Everything is on schedule—and might even go a day early because things are going so well. Two space shuttles, the Atlantis and the Endeavor, are being readied for use.

***Extrasolar planets***
Our knowledge of extrasolar planets is soaring. Astronomers have used various techniques to identify 344 extrasolar planets as of April 10, 2009. The most powerful technique thus far is the radial velocity method--where scientists look at the star very carefully and look for the wobble in the star because of the planets orbiting it. Using the transit method, one looks for the slight diminution of light when the planet passes in front of the star.

Of the 344 extra-solar planets identified as of April 10, 2009, about 300 planetary systems now have been found. Most of the stars have multiple planets around them; to date, 291 stars have been found to have planets; only 53 searched had negative results. The smallest planets have a mass several times larger than the Earth. No habitable planet has been found thus far.

Scientists found tremendous surprises—such as many Jupiter-sized planets, called "hot Jupiters" as close (or closer) to their star as Mercury is to the Sun. The planets were not formed there—so the next surprise was the discovery that planets move around. They do not stay where they are formed. In our solar system, all the planets have very close to circular orbits, which would be zero eccentricity. Extrasolar planets are found with an amazing range of eccentricities. The first planets to be found were discovered around neutron stars, to the scientists' amazement.

The Kepler mission was successfully launched March 7. (The dust cover was jettisoned on April 7, 2009. It is now going through its testing.) The Kepler goal is to detect Earth-like plants--planets that are 1 astronomical unit (the Earth-Sun distance) from their star and have a mass like the Earth. This formerly had been beyond the sensitivity level of other telescopes. Kepler will study and monitor brightness of 100,000stars and look for transits of Earth-sized (and other) planets.

***Planning: Future of Exoplanet Exploration***
Exoplanet exploration is an exciting and rapidly expanding area of research in astrophysics. The goal is to image a planet and find some kind of evidence for life. Exoplanets are going be a major topic for the astronomy Asstro2010 Decadal Survey that is currently taking place—about a third of the survey has been completed. The Astrophysics Subcommittee (APS) and the NASA Space Mission Directorate (SMD) want tactical input from the community because expert analysis is needed to shape the program.

The Science Committee offers the following recommendation:

**Form an Exoplanet Exploration Program Analysis Groups under the Astrophysics Subcommittee.**

> **Recommend NASA form an Exoplanet Exploration Program Analysis Group (ExoPAG) to conduct analyses at the request of the NAC Science Committee, the Astrophysics Subcommittee, and SMD. The ExoPAG will take direction from APS and report to APS.**

This is not a free-standing group but will be supervised and directed by the APS.

***Heliophysics***
Dr. Charles Kennel noted that this year is the 50th anniversary of the first scientific discovery using a space satellite (Explorer 1, which discovered the van Allen radiation belts). A slide presented Solar Terrestrial Relations Observatory (STEREO) views of Earth-impacting coronal mass ejections. There were two different views of the solar flares –the explosion of the solar flare and the plasma lighting up the atoms as it goes through. It then propagates out into the deeper solar system towards Earth—and when it

hits the Earth it will cause a magnetic storm, which can produce severe disruptions in communications. This is the first time a satellite has given scientists the opportunity to see the propagation of the solar flare and to see it hit the Earth. Dr. Kennel commented that seeing these ejections was a unique experience, something he had never seen. He said that it looked like energetic particles were being shot out the poles of the Sun. This makes the solar system a model for the plasma interactions that occur in the accretion discs that surround black holes and quasars. Dr. Kennel observed that this unique scientific tool allows scientists to study these ejections as never before. It is an opportunity to study these phenomena directly, and thus scientists can begin to confirm through direct observation what the astrophysicists have thought they understood theoretically for a number of years.

***NRC Heliophysics Performance Assessment***

The Heliospheric science program recently had a mid-term review. The 2005 NASA Authorization Act requires that the performance of each division in the Science directorate of NASA be reviewed and assessed by the National Academy of Sciences at 5-year intervals. It asked that each Division have a periodic review of progress in implementing the suggestions of the National Research Council. This review report was recently conducted by the Space Studies Board, and NASA is in the process of preparing a report to send back to Congress in response.

The Committee heard the response in preliminary form. The Committee recommends that the Heliospheric Physics Subcommittee take up this matter, study it in detail at their next meeting in May, and report to the Science Committee in a subsequent meeting.

Dr. Burns expressed his enthusiasm for all the advances being made. He said that the material presented gives an idea of why scientists are excited about not only the ongoing work but also the future potential in working with NASA probes at all scales—"from the Sun to the most distant universe into the cosmological regime--seeing the Sun blasting Venus and Earth and trying to understand the consequences all the way out to the interaction of galaxies and the prospect in the next decade of detecting Earth-like planets. What could be more fun than that?"

***Phoenix Lander Data***

Dr. Brad Jolliff mentioned the recent 40th anniversary of the Lunar and Planetary Science Conference that parallels the 40th anniversary of Apollo 11. The conference was held in Houston in March and had a record attendance. One conference highlight was the discussion of the physical evidence for water brines on Mars from the Phoenix Lander. These results are undergoing peer review to explore the possibility of liquid salty water or brines on Mars. It is a merely a hint of the good results coming from the data collected from Phoenix.

***Vortices on Venus***

Dr. Mark Robinson discussed a slide showing two composite storm images that compared Venus with Earth. The Venus storm image was taken by a European space agency spacecraft, Venus Express, which has been in orbit around Venus and has been sending back repeat observations— which scientists need to increase their understanding of the climate of that planet. Venus has an atmosphere about 90 times as dense as Earth's atmosphere—so it has a different thermal and pressure regime, but there are more philogic storms than on Earth.

The other image (taken recently by the NASA satellite) showed a hurricane on Earth and a cyclone on Venus. There are large differences in scale between the two storm images. The cyclonic storm on Venus is about 12,000 kilometers in diameter and the hurricane on Earth is about 1,000 kilometers in diameter. Even more significant is the scale in terms of time. The hurricane on Earth lasted for a week or two—but the storm on Venus was discovered through Mariner 10 data some 35 years ago and is still raging. It continues to be observed by the European space agency's spacecraft.

There are different dynamics taking place in the atmosphere of the two planets—not surprising since their atmospheres are very different. This is more of progress report in understanding comparative climatology. Right now scientists do not have a good understanding of what is occurring in the Venus atmosphere although a recent paper ["Geophysical Research Letters" published February 28, 2009] presents a good numerical model of examining the vortices in the center that are similar to Earth. As scientists get more and more repeat observations, they can see how this storm is changing with time and understand better how climate works on Venus and therefore how climate works on Earth.

Dr. Burns noted that Venus is a very important planet—it is a virtual twin to Earth in terms of mass, radius, density, and gravitational field yet it has a very different atmosphere. How that much thicker atmosphere has evolved and what scientists can learn from that atmosphere relative to the evolution of the atmosphere of the Earth is very important. Having a twin sister in our solar system with a very different atmosphere is a unique opportunity to understand our own atmosphere. He further observed that Earth's atmosphere is very complex, and our best models running non-linear physics calculations "still have a long way to go." Having data from another planet is very helpful.

***Plutonium-238 Supply***

During the fact-finding session, NASA's Planetary Science Division Director, Dr. Jim Green, presented a slide that illustrated the magnitude of the shortage of plutonium against potential NASA demand. The existing supply, including the plutonium purchased from the Russians, will run out in 2020, about the time that NASA astronauts first return to the Moon.

The U.S. no longer has the capability to generate its own Plutonium-238 —so it has to purchase its supply from the Russians. The ongoing issue is restarting reactors to generate our own supply. The U.S. will need our own reactors because, as we travel to the outer reaches of space and as we go back to the moon and establish outposts, a larger supply of Plutonium-238 will be required to fulfill the power demands.

For the next few years, the Plutonium-238 supply is adequate—but as the end of the next decade nears, the supply will not be adequate for NASA's needs. For the next generation of discovery missions, the demand increases substantially. Even if a U.S. reactor is built, the demand will outstrip the supply. This takes into account only civilian needs and not Department of Defense needs, which add to the strain on the overall stock pile.

Dr. Gerald Kulcinski commented that the main point is the time lag that occurs between the decision time and the time that plutonium is needed. Five years can sometimes occur between making the decision and actually getting the plutonium to the spacecraft. Long-range planning is absolutely essential.

General Abrahamson asked if we were fortunate enough as a world to reduce the supply of weapons both in U.S. and Russia, could plutonium be easily diverted from weapons into these engines. Dr. Kulcinski answered that weapons-grade material uses Plutonium-239—but we need a supply of Plutonium-238. Plutonium-239 is not really an option to power a radioisotope thermoelectric generator. Taking Plutonium-239 from weapons would not solve our problem and would have no effect on supply of Plutonium-238.

Dr. Burns emphasized that this is a matter of urgency. The timeline is growing short, so deliberations with the Department of Energy should begin as soon as possible. The NAC has previously made several recommendations along these lines, and the Science Committee urges the need for much more progress quickly.

***Earth Science***

Dr. Byron Tapley addressed the group by phone. He stated that the context of his remarks is NASA's role in climate change. He noted that NASA had a "requirement creep" that was a result of its own success. The increase in requirements was a main topic of the Science Committee's meeting.

Addressing global climate monitoring, he asked the group to look at the two slides taken in the Antarctic—one image was taken on March 31, 2009, by Terra MODIS and the second slide was taken on April 6, 2009, by Aqua MODIS. These slides illustrate NASA's ability to go into a hostile environment and monitor and interpret the changes and processes that are occurring.

The first slide shows the ice bridge running along the land that is restraining the Wilkins ice shelf. On April 6, the image picked up a dramatic change in the nature of the ice shelf, which had essentially collapsed. Since the collapse of the ice bridge connection to Charcot Island a few days earlier, icebergs from the disintegrated ice shelf appear to be moving farther away from the Antarctic Peninsula, towards the open ocean. The remaining part of the ice shelf's connection to Latady Island is also thinning. Large cracks near the island can be seen. Once the ice shelves go away, the restraining part of the glacier is gone and the melting of the ice into the ocean accelerates. This is a manifestation of the warming that is affecting the Wilkins ice shelf.

***NASA Earth Science in the Interagency Context***

Dr. Tapley said that NASA's earth science satellites are essential to global climate monitoring. The Earth Observing System is the space-based component of the nation's Climate Science Program. It provides the means for NASA to go into these different regions, monitor them, and tell the world what is happening in these systems. But the national requirements for Earth observations from space presently exceed the available resources. The NRC's decadal survey recommended missions that cannot be implemented in the indicated timeline. The survey also recommended an integrated slate of missions that would require simultaneous observation of several key parameters. In addition, NASA has requirements for a number of other missions, not contained in the survey, which are not funded.

Addressing all the requirements is a national responsibility. Interagency collaboration is a crucial key to meeting the requirements. NOAA is an essential partner—but it also faces budget shortfalls. In addition, the partnership with the National Polar-orbiting Operational Environmental Satellite System (NPOESS) may not provide the long-term climate data records needed for climate change research.

Dr. Tapley discussed the chart that displayed missions classes divided into four boxes: (1) Foundational (Glory, Aquarius, NPP, LDCM, and GPM); (2)Decadal Survey (Venture-Class, SMAP, ICESAT-II, Clarreo, and DESDynl (SAR, LIDAR which includes five Tier 2 missions and six Tier 3 missions); (3) National Needs (Carbon Recovery (vice-OCo), TIRS (LDCM or free flyer), DSCOVR, SAGE III, Gifts; (4) Climate/Operational (other agencies) that included Vector Winds (vice QuikSCAT, Space Weather (vice ACE), Ocean color, Aerosols (vice MODIS), Nadir Altimetry (vice OSTM/Jason-2), GPSRO, Broad-band Radiation Bud (CERES) and R20 infusion.

The foundational missions have been funded for implementation. The budget for these missions is in place. The Decadal Survey missions, a key assignment of this decade, require a budget of $15 billion overall—but the annual mission budget is $1.27 billion. Dr. Tapley noted that if NASA were to put all of its available funds into meeting the Decadal Survey requirements, it would be stopping most other Earth Science Division (ESD) charges.

The Climate Operational box shows the capabilities that have been developed previously by NASA that play an extremely important role in both operational and planning-related activities. These essentially are suites of measurement in satellites, but they are in various stages of process. These missions are unfunded and could be handed to other agencies.

Dr. Tapley explained that no existing or planned near-term satellite sensor will duplicate the Orbiting Carbon Observatory's (OCO) unique contributions to carbon cycle and climate science, which includes accuracy, stability, precision; coverage; spatial resolution, and rapid global repeat. There is a growing interest in the policy community for actionable information on $CO_2$ sources and sinks. No near-time carbon recovery mission will be possible without new top-line funds to ESD. Without these funds, significant delays to ongoing and decadal survey missions will occur.

**Recommendation: Process for identifying non-science requirements and funding for Earth observations.**

> **NASA should work with OSTP and other agencies at the highest levels to define responsibilities and secure funding for Earth observations beyond those recommended by the Decadal study to advance Earth System Science.**

Dr. Burns cautioned that the portfolio given to the ESD is not sustainable. It requires a set of responsibilities that far outstrip the available budgets. It needs a broader inter-agency level of coordination and discussion that goes beyond what the ESD can do.

Dr. Burns warned the Division does not have the budget to carry out all the Decadal recommendations (or to meet the Congressional mandates and operational needs). The crisis in ESD cannot be solved by itself or NASA alone —it requires an involvement of the White House and other agencies. Preliminary discussions have begun; and an acceleration of these discussions to solve this set of problems is urged. The strain on the ESD's resources cannot continue. The expectation levels are much higher than can be delivered.

In response to a question about integrating and coordinating the portfolio elements, Dr. Burns said that there needs to be a national strategy devised. He noted that strategy development is crucial and is a priority of the current Administration. It can only be developed with broader based discussions beyond the ESD. Certainly the science community will participate fully, but the national needs and climate/operations requirements go beyond the science community's ability to respond.

It was noted that NASA has led U.S. government sectors in working internationally in the areas of science and exploration. This is most clear in many of the scientific missions. The question was asked about coordinating and investigating capital investment or in-kind activities with other nations' space programs. It was noted that we see other nations' spacecrafts flying—but do we need to consider working with them at this planning level? Dr. Burns responded that this is an excellent question and one that the Committee wrestled with in some of its sessions.

Dr. Tapley noted that significant resources are being added to all space operations, especially Earth science. Successful bilateral and trilateral cooperation on specific missions have taken place, but there needs to be international collaboration on a broader scope. He has not seen much progress in the international community's ability to get together to assess and divide up the overall requirements and produce a coherent plan.

Dr. Burns thought that part of the difficulty is that the responsibility for climate is spread over a number of agencies in the U.S. Presently there is no single point of contact with which to negotiate with the

Europeans, who are more centralized. He said that we first need to get our own priorities in order by preparing our national strategy and defining responsibilities for climate—and then be able to go forward in addressing international collaboration.

*Space Communications*
As NASA begins these next set of ambitious missions in science and human exploration, breaking out of earth orbit and going to the moon, it is important to consider space communications capabilities. NASA communication's infrastructure is aging and is overtaxed in returning all the data from current planetary missions while the number of missions and data rates is increasing. When NASA begins human lunar exploration missions, the data rate requirements will be high. To return all the data from current planetary missions and the next generation of planetary missions, it is clear that we are reaching a shortfall. For the future of the next generation of human exploration and solar system exploration, space communications capability needs to be expanded. The Science, Exploration, and Space Operations Committees are recommending a study of needs assessments and capabilities (to include a look at the Deep Space Network) that should be undertaken now, for there is no time to be wasted.

**Recommendation: NRC study of space communications: requirements, capabilities, and architecture.**

**Recommend NASA task the NRC to conduct a study of space communications needs for science, exploration, and space operations including:**

- **Assessment of needs**
- **Assessment of new and emerging communications technologies**
- **End-to-end view of the communications system**
- **Identification of future capabilities that may not be available commercially**
- **Identification of factors including cost that should define an optimal mix of optical communications, radio arrays, and other techniques**
- **Consideration of international and interagency plans**

Col. Collins said that her Space Operations Committee, along with the Science Committee, looked at this subject in October. The committee was concerned that the requirements need to be more quantifiable and specific or there is a danger that the resulting program is not efficient, is over budget, is not on schedule, and does not meet NASA's needs. She said further that she was not sure that it was necessary to outline that concern in this particular recommendation, which is broader. She did want to say, for the record, that a later recommendation about quantifiable, more specific requirements should be considered. Otherwise, she felt what is being recommended is very well-thought out and needs to be done.

General Abrahamson noted that it will be expensive to fund the revitalization of NASA's infrastructure. It is similar to the problems our nation is experiencing in revitalizing its infrastructure. It is an excellent idea that an independent agency such as the NRC can reach across interagency plans and can assist with the necessary independence and motivation to find the funding, based on the needs. NASA, historically, has reached outside itself in the past—even in the area of space communications--but it is necessary to ensure that plans are fully integrated and be synergistic with other agencies.

## Human Capital Committee

Dr. Kulcinski discussed a displayed graph showing the aging of the NASA workforce over the past four decades. In comparing the Apollo (1968) and the Shuttle eras (1983), a disturbing trend emerged, revealing that NASA currently employs very few young people. He stated that there has been some progress in reversing this trend. NASA now intends to set a goal of 50 percent of its new hires in FY09 to

be fresh-outs—defined as graduates within three years of their degree. In addition, the intention is to hire approximately 200 to 300 fresh-outs in the remainder of 2009. The objective is to restore a more normal workforce demographic. The Committee had some minor concerns:

- OIG is making sure that this policy does not violate age discrimination regulations. NASA will use Federal Career Intern Program Authority that allows new hires to come in at an intern level.
- What about a change in mission that could impact hiring? In assuming that Constellation will go forward and if there is a change in direction, NASA will require staff with specific skills and background.
- For the initial 200 to 300 new fresh-out hires, how can NASA in such a short time guarantee the quality of applications/selections? Most graduates (especially high aptitude students)—those that are graduating next month—have already received job offers for FY 09.

Dr. Ford asked if the briefers talked about the methods NASA would be using in attracting the new people. Dr. Kulcinski said the details were not shared with the Committee.

In discussing other policies to improve the NASA workforce, Dr. Kulcinski stated that the Committee strongly supported the policy that directed the Office of Human Capital to begin the fresh-out recruiting initiative in May and to make offers to the December graduating classes for jobs in FY2010.

One striking development is that the next generation of employees in NASA is more interested in the rewards of being at NASA such as attending shuttle launches rather than being motivated by monetary or visual rewards, e.g., medals. The Committee offered the following recommendation:

**Addressing NASA Workforce Demographics**

> **Recommendation: In order to balance the demographics of NASA's aging workforce, NASA should pursue raising the current OMB-established workforce ceiling to increase the hiring of entry-level talent.**

The average age of NASA workers is approaching 50 and the practice of hiring contractors instead of college graduates is aggravating this shift. Right now the average age of hiring is 42—and there are very few scientists and engineers below the age of 30. It is important to take an aggressive approach in hiring students early in their careers and to have the reasonable goal of returning to the age demographics of the Shuttle era.

If there is no action on this recommendation, the Committee warned it could rob NASA of the many new and fresh ideas that could contribute to the Constellation program. It could also result in future retirement crises previously unseen in the federal government. The lack of hiring graduates fresh out of college will slow down past progress in addressing diversity and inclusiveness of the programs of the NASA workforce. It will also be more difficult to compete with other space-faring nations on the exploration of the Solar System.

Dr. Burns asked if, when talking about competing with other space-faring nations, there might be a possibility of hiring qualified persons from other nations who are currently in this country—and who NASA might benefit from hiring rather than seeing them go back to their own countries. Dr. Kulcinski responded that generally NASA does not hire non-citizens. Out of 18,000 NASA employees, less than 20 are non-citizens.

Another participant observed that in discussing young people wanting to participate in the full life of the agency, it would be good to look at the practice of private industry. When pursuing top talent, his organization hires people with the understanding that they will get the benefit of full exposure to all

programs. He asked if NASA has a similar program where it can send people to the different centers to be exposed to the agency and the agency can be exposed to them.

Dr. Lucy Fortson answered that the Committee was briefed about current mentoring actions in which they rotate people to the various centers. Dr. Kulcinski observed that the mentoring program seems to be very strong and will get stronger in responding to that generation. It will have an emphasis on involving young people in getting acquainted with all aspects of operations. These were action items that were identified by a cross-generational team, whose members were very cognizant of the point brought up.

Dr. David Longnecker said that in talking about a "normal distribution" that is different from the Apollo era, he was slightly uncomfortable with using the term "aging." Aging demographics is occurring in society in general. While he applauded the idea of hiring fresh-outs to bring new thinking and ideas into NASA, he cautioned that candidates could include a 45-old woman who dropped out and delayed her degree in aeronautical engineering to raise a family and subsequently returned to a university and earned her degree. Another example would be an auto employee who lost his job and has gone back to school and got his degree in accounting and comes to NASA as an employee. These types of hires also bring fresh ideas and perspectives. He urged the group to be aware that it is not just age that should be a consideration in a new approach. Dr. Ford concurred, saying that the emphasis should be on fresh and new ideas, rather than age.

Dr. Kulcinski stated that the Committee's diversity and inclusion briefing indicated that NASA's diversity programs were in good shape. Complaints were low in 2008 (0.3 %). In an independent assessment, NASA ranked 10th in EEOC rankings of 58 agencies in the Federal Government. The Diversity and Inclusion Program will continue to advance NASA's efforts to be a model EEOC agency.

***Use of Co-ops in Hiring***

Ms. Terry Robinson from the Office of Human Capital Management briefed the committee on the use of Co-ops in hiring. Entry-level hires were less than 37 percent over the past 5 years (2004-08), which is a little different from the data the Committee received at the last meeting. The data shows that the Co-ops have constituted 41 percent of the entry-level hires. The Committee will continue to follow these data results.

***NASA TV Recommendations Revisited***

The Committee has re-evaluated the recommendation made a year ago in April 2008. The original recommendation is still felt to be valid, but the Committee incorporated recent fiscal and organizational information for its current recommendation.

**Recommendation: Resources be provided to an outside organization to conduct an agency-wide evaluation of the current content, effectiveness, and viewership of NASA TV and to recommend a clear rationale for its most effective utilization. This outside entity should take into account the NASA internal 2007 review of NASA TV as well as new web-based initiatives. The outcome of this study should include recommendations for the level of resources required to most effectively engage the public and disseminate NASA content.**

Rear Admiral Benjamin Montoya advised the committee to substitute the word "plan" for the word "rationale" in the recommendation. Dr. Kulcinski agreed to this change.

Clearly the present resources are not adequate to do all what NASA wants to do. NASA TV was initiated, in part, to support the Shuttle program. It is reasonable to reassess that decision in light of the planned Shuttle retirement in 2010. The emergence of internet-based delivery further supports the need to examine this program. Understanding the effectiveness of the current program and the viewer

demographics of viewers will assist the Office of Strategic Communications in targeting efforts to develop online infrastructure. This would enable NASA TV to be more effective in the future.

Dr. Burns said that he wanted to applaud the Committee for being persistent concerning the last recommendation. He noted that this topic seems to be discussed at every meeting—and there seems to be resistance. He felt that an outside evaluation would be good. He said that he recently had an introduction to the new technology and there is a need to keep up with the next generation's way of communicating, which is with the internet, texting, Facebook, twittering, etc. rather than relying on TV. He observed that NASA needs to be more innovative in directing its marketing efforts to young people. He expressed his approval of the Committee's exploring alternate methods of communication and marketing. Dr. Ford disagreed with the assertion that the younger generation does not watch a lot of TV. He felt the recommendation is about improving TV—not abandoning it. Dr. Owen Garriott said that the question remained whether NASA is providing the needed funding for the TV content.

## Space Operations Committee

A huge milestone for the space station program occurred on March 15, 2009, when STS 119 was launched. It delivered and assembled the fourth starboard Integrated Truss Segment (S6) and the fourth set of solar arrays and batteries to the station. The STS 119 has enough power to power 50 single family homes. The space station is 81 percent complete by mass and 84 percent complete by volume. Col. Collins said the committee members have followed very closely the preparation to go from a three-person space station crew to a six-person crew. To make that happen, all the major milestones are complete except the water recycling system. Repair parts were taken on board and the system has been repaired (except for a few minor details that Houston is still working on), and the recycling system is ready to go. About 78 percent of the crew's air and water will be recycled and reused.

Col. Collins showed a video of the fly-around and described the major components of the Space Station. In answer to a question about the location of Colbert [the Combined Operational Load-Bearing External Resistance Treadmill named after the comedian, Stephen Colbert], she said it will eventually be in Node 3. Col. Collins said the ISS is approximately the length of a football field with an inside volume of approximately 32,000 cubic feet, equivalent to the volume of a Boeing 747. The station has plenty of power, which is no longer an issue. When the station is in the shadow of the earth, it gets its power from batteries.

***ISS Program Update***

Mr. Jay Greene reported that the space station assembly is virtually complete. The last flight delivered the last of the US-built elements to the space station. The fact that it went all went together with few problems is an amazing accomplishment. There are two elements remaining, Node 3, which is being built by the Italians, and the Japanese external research facility, which fits on the back of their module. In May of this year, the space station will go to a full complement of six crew people. The environmental life support systems are activated, and the water recovery system is in operation. Crew and cargo flight planning are continuing. He added that in September, the Japanese module will go up and during the remaining Shuttle flights, NASA will continue to get as many critical flight spares stored at the station as possible and continue to outfit the laboratories.

***Shuttle Update***

Dr. Pat Condon described the highlights of a chart showing the flight assignment working group planning manifest. Nine remaining shuttle flights are shown in three levels: the Discovery flights, the Atlantis flights, and the Endeavor flights. The bottom of the chart listed the flights that are planned by NASA's international partners.

The next flight will be the Hubble repair mission with Atlantis serving as the primary vehicle. Endeavor is the rescue vehicle, should that be required. All remaining shuttle flights will be launched from Pad 39 A. The Endeavor will soon be rolled out to 39 B to prepare for a rescue, if needed. (If not needed, it will be removed from Pad B.) Preparations for the Ares 1X launch will begin, and Ares 1X will be launched from Pad B this summer. There will be no further shuttle launches from Pad B.

In May, the Space Shuttle Atlantis' STS-125 mission to repair the Hubble Space Telescope is scheduled to be launched. There will be Japanese pieces of equipment that will go up on that mission. The Japanese Experimental Module is an external module that some refer to as a porch. The next shuttle flight after Endeavor will be Discovery, which will have a mini-pressurized logistics module. As mentioned earlier, the Colbert will go up on that flight and reside temporarily in Node 2. When Tranquility is installed, Colbert will be moved to Node 3.

In October, Atlantis will go up, which will be basically a cargo mission. Then Endeavor will make a flight when Tranquility will be taken up to the station. In March to April in 2010, Discovery will make a flight with another pressurized logistics module. The remaining two flights will be the Endeavor in about the August time period and Discovery in late September. These last two flights are in the planning queue, but they are not formally on the manifest at this time.

In the period from October 2009 to September 2010, there are six flights scheduled for that one-year period. It has been eight years since NASA has had six shuttle launches in one year. Previously it was launching from two pads whereas these flights will launch from one pad. Three additional crew men are scheduled to be added in May. The Japanese flight will be scheduled to go up in August.

In a question about the volume of Payload B, it was noted that it looked as if there is volume available or open. Col. Collins said that the launches are completely full. In response to a question about whether the flights could be stretched over a slightly longer period of time if there weren't such a tight deadline, Col. Collins replied that she did not think the schedule is being unduly driven by end-of-the year concerns. There is flexibility and planning built in—and if the need arises, the schedule could be extended.

Dr. Pat Condon talked about the Committee members being briefed on an aerodynamic experiment performed by NASA engineers. On the left side of the shuttle's wing, engineers removed several tiles for boundary level experimentation. A Navy 3-P Orion was equipped with long-range infrared (IR) camera. When the shuttle was reentering the atmosphere at about Mach 15, Orion was able to image the underside of the shuttle with its IR camera. The protrusion tripped the boundary layer earlier than it ordinarily would have been tripped and produced turbulence behind that particular tile. NASA wanted to understand what kinds of heat loads would be generated on the back downstream of this tile. They wanted to better understand what would happen if some of the gap filler protruded beyond the surface, as they had experienced in the past and actually had repaired, and how much protrusion was a matter of concern. Gap filler can shake loose during launch and extend up into the airflow, triggering an early, asymmetric boundary layer transition during re-entry. When that happens, the shuttle's aerodynamics can be affected and downstream tiles can be subjected to more extreme heating. Any bulge or protrusion on shuttle heat shield tiles could trigger turbulence. If it occurs early in re-entry, when the velocity is higher, the tiles are exposed to greater temperatures for longer periods of time. Resulting damage could breach the orbiter's heat shield, endangering the spaceship and the astronauts.

***Orbital Debris Update***

Dr. Tom Jones spoke about the briefing on debris given by Gene Stansbery of the Orbital Debris Program Office from the Johnson Space Center. Orbital debris has been in the news lately (and will probably continue to be) because the population of debris around the Earth has increased throughout the years.

This was vividly illustrated in the sequences of slides that showed the dramatic increase in debris from 1960 to January of 2009. The debris population has begun to expand exponentially because of collision of these fragments, which has led to the seriousness of the situation. Dr. Jones noted that there was "not much good news in the picture." He jokingly observed that if debris continues to increase, we won't have to worry about global warming because the debris will be shielding the Earth from the sun.

The Space Surveillance Network can currently track debris that is bigger than a softball. The Network contains a host of radars and optical tracking devices and gets supplemental data from a couple of radars in Massachusetts that have smaller samplings. The chart shows the potential ramifications of different sizes of debris. At point 0.01 centimeter, the debris hitting the window would necessitate a window being replaced. Dr. Jones said that on one of his flights, he saw a pit in the outer pane of the three panes of window glass about the size of a pencil point with rings of disturbed glass around the pit from an impact from something as tiny as a grain of sand. He noted that on a space walk, a space suit could be penetrated with something a tenth of a millimeter in size. Debris impact is a concern of people working outside and in the cabin. There can be radiator or tile penetration, and the shuttle cabin could be penetrated by something under a centimeter in size.

Dr. Jones explained that there are some gaps in the sensor coverage. The Space Surveillance Network tracks larger objects; the Haystack Radar provides estimates in this size range. Dr. Jones said that there are gaps where we do not have good estimation of the debris population, and so we extrapolate.

A NAC member asked if the debris is essentially moving in the same direction. Dr. Jones replied that the debris can come from any direction. There are a whole host of orbits and collisions that can occur from any direction. He further explained that as the space vehicle flies in its own orbit, it can run into things—there is a Ram direction preference to hitting debris, but the vehicle can be struck from behind as well. Orbital velocity is 7 kilometers per second. NASA presently only tracks and catalogues man-made debris that is 10 centimeters and larger. A graph showed the increasing number of collision fragments, which has increased quite rapidly since the 1960s.

Dr. Jones noted that the ISS has probably been hit but has not yet been damaged by debris. It is the most heavily protected space vehicle with more than 200 different types of shields to mitigate the effects of small particle hypervelocity impacts. The U.S. Laboratory has debris shields on the outside; it is designed for a 15 or 20-year lifetime in space. The debris shield's construction involves an aluminum shield about 2 tenths of a centimeter thick that can fragment an incoming piece of debris and those fragments will strike a tabular fabric blanket a couple of centimeters below it, which will catch the remaining fragments and slow them down and further fragment them. Then there is the hull of the spacecraft itself, which is about 1/3 inch thick. The space station's major modules (such as the lab) are built to be protected from a piece of debris up to about 1.3 centimeters across.

Anything larger than that measurement is predicted to penetrate the pressure hull. This could happen some time during the lifetime of the space station. If a larger piece of debris hits a vital pressurized component, the crew will probably have to evacuate that module or put a patch over it if they can see it—which is unlikely—and they will probably have to evacuate to make the repair in a vacuum or go outside to repair the puncture. Since January 2007, the number of catalogued objects has increased by more than 30 percent. The catalog currently has more than 14,000 objects being tracked in orbit. Dr. Jones discussed the impact of recent orbital debris events such as the Chinese weather satellite, the ASAT test, and the Iridium-Cosmos collision.

A graph showed the anticipated evolution of collision debris clouds over 7 days, 30 days, 6 months, and 1 year. Dr. Jones warned that this is a serious situation and has reached the point where this concern cannot be ignored in terms of long-term planning. The number of catalogued orbital debris objects has increased

by more than 30 percent in the past two years. On March 12, 2009, a piece of debris came close enough to the International Space Station (ISS) to require the astronauts to take refuge in the Soyuz module for 11 minutes. Events like these will probably be happening more and more. Long-term solutions and a more aggressive program to address the orbital debris environment are still needed. The recent high-profile events have raised the awareness of orbital debris issues. There is no practical technology to remove debris at a reasonable cost. The Committee members felt that active degree mitigation needs to be studied in more depth.

**Recommendation: We recommend that NASA conduct an in-house study of the current and projected orbital debris situation to evaluate the costs and benefits of developing a form of debris removal technology. The study should compare the costs of operating in the ever-expanding debris population with those of developing a selective debris removal method and how those compare with long-term savings from actively reducing the threat of future collisions. We also recommend that NASA examine enhancements to the nation's debris detection, track, and prediction capabilities that will enhance spacecraft.**

The growing debris population, expanded significantly by the recent collisions, poses a continuing and increasing threat to operational spacecraft. Despite international protocols on preventing the creation of future debris, the debris population will continue to expand for decades, well past the middle of the century. Gaps exist in U.S. detection capabilities, especially in detecting smaller debris sizes that can cause catastrophic damage to spacecraft. The projected debris population will, over decades, result in additional damage to or loss of spacecraft, and poses a growing threat. NASA may be able to offer methods to actively reduce the debris population, which will produce benefits that accrue to commercial, military, and NASA spacecraft.

In response to a question about working internationally, Dr. Jones noted that the UN had a working group dealing with debris. The actions of the group have resulted in the major space-faring countries reducing their input into the debris population such as removing their spent boosters at the end of their service and re-orbiting de-activated satellites via these protocols, but not everyone, such as China, has signed up for it. Dr. Kulcinski had questions about whether NASA tracked some of the Russian debris, including ejected control rods and fuel rods, which released a lot of sodium potassium spheres. Some of the fuel rods have some radioactivity. Dr. Jones said he would investigate the answers to these questions and let him know by e-mail.

Capt. Rick Hauck spoke of one of his committee's briefings where a representative from the Systems Engineering and Integration Group for Constellation said that the greatest threat for loss of crew (LOC) for Orion is forecast to be orbital micrometeoroids and orbital debris. For any given shuttle mission, NASA views the debris risk as much of a risk to the shuttle and crew as the launch. Col. Collins noted that a typical shuttle mission's risk ratio of LOC and vehicle from micrometeoroids and debris as 1 in 250—but the upcoming Hubble mission risk is 1 in 185 because of higher altitude exposure to debris.

Dr. Logsdon pointed out that NASA is just one of the stakeholders in addressing the concerns about debris. The National Security Council takes the challenge of space debris very seriously. It was suggested that of the wording of the recommendation be modified to reflect the reality that this is a national issue with the Air Force taking the lead.

The question was asked whether there any active sensors either on the station or on the large objects like the Hubble that record impacts of debris. Dr. Jones answered that there are none, but the space shuttle has main wing sensors that were installed on the wing edges to record the time and location of any debris impacts since Columbia. Those are battery powered and relay the information on a wireless loop back to the cabin. Col. Collins noted that the impact sensors used in 2005 had not worked as well as NASA had

hoped for. At the end of a space shuttle mission, the crew uses the robot arm sensors to check for debris damage.

***Commercial Orbital Transportation Service (COTS) and Commercial Resupply Service***
Rear Admiral Benjamin Montoya talked about the committee's visit the previous day to the Orbital Sciences Corporation near Dulles Airport. He said that the presented information was provided by the corporation and had not been validated independently by the committee.

This company, founded in 1982, made its mark in business by developing and manufacturing small satellites and launch vehicles. Company officials emphasized that it was a conservative company with a strong balance sheet, good revenue, and a strong cash flow. This company is highly effective in buying and integrating system components and testing them to reach the final product. The company has a COTS contract and, because of its progress, NASA has awarded a follow-on contract to provide commercial resupply services to the space station.

The Orbital COTS System has four major components: the Cygnus visiting vehicle, the Taurus II, Cargo Operations, and integrated launch site operations. The company has its own mission operations center. Their preferred launching location is Wallops Island. Other launch sites are available to personnel as part of their mission structure, but they will be doing most of their initial work at Wallops Island and will be using the Taurus to launch vehicles. When they get into space, they plan to berth with the space station by the use of a grappling arm.

The company is under contract for eight operational missions between 2011 and 2015.for the purpose of carrying pressurized cargo to ISS and returning with disposal cargo from the space station. CRS missions three through eight will have enhanced, larger pressurized cargo module using an enhanced Taurus II missile. The service module is designed to be compatible to the two sizes of cargo modules, pressurized or non-pressurized.

The next slide showed the dispersal of their launch sites, the primary one is that of Wallops Island, but they also have capability at Cape Canaveral, Vandenberg Air Force Base, and Kodiak, Alaska. When a company official was asked why one site was at remote Kodiak, the answer was some states are more generous than others in helping out financially and Alaska welcomed the company to operate in its state.

The first launch will be in 2011. The committee also was able to visit the company's work on another contract at the Orion Launch Abort System. The company is proud of its progress and provided a list of accomplishments.

The Space Operations Committee has now visited facilities of both COTS Space X and Orbital Sciences companies—and are pleased and optimistic about what they have seen. Both companies seem well-staffed and capable. Col. Collins said that one of the major issues of the Space Operations Committee is tracking the utilization of the space station, so the success of the COTS program and the CRS contract is extremely important to the space station. NASA is still on track to retire the shuttle at the end of 2010 and Orion will not be ready until 2015, so there is a gap in human space launch. Consequently the COTS CRS program is the only thing NASA has to fill the gap for cargo launch. It is important that these companies succeed for our effective utilization of the space station.

***Utilization of the Space Station***
Dr. Owen Garriott said that the committee had been briefed by Dr. Julie Robinson, the ISS program scientist, and Mary Beth Dean of the ISS National Lab office. Scientists, engineers, technicians, and commercial operators need to get access to "this $50 billion piece of hardware that we have managed to

get fully into space." Dr. Garriott observed that without the final utilization step, "this has been essentially been work for not much value in return."

Opportunities will be provided to other U.S. government agencies (such as NIH, NSF, etc.) and commercial entities to participate in this activity and get some of their experiments and payloads flown on the ISS, where crew members will conduct the experiments. The Space Act Agreement is in place with NIH.

Dr. Garriott said that we have to talk about funding parallel to the other activities. NASA will not be paying for the payload development costs or the launch costs for the outside entities to get their payloads up to the ISS. It will be paying integration expenses for the operation of that experiment and crew members will be available to conduct the experiments.

A slide displayed the activities of Expedition 19/20. The number of disciplines being represented is substantial. Some of the research outfitting on board include a wide range of human research racks, express racks, a glove box, and a number of freezers located in various modules (so that samples will not be lost). Combustion experiments can be done on one of the racks. A wide range of facilities will be available to those who get their experiments on board.

Dr. Garriott discussed a complicated graph entitled "Partner Utilization Requirements Compared to Utilization Capabilities" that showed NASA capabilities. He felt the important point was noting the 500 metric tons of capability that can be taken up to ISS. NASA is currently using approximately 2/3 of the up-mass capability. A substantial gap exists between the plans for the utilization and the capabilities of ISS. Requirements below the line are in excess of partner allocations. The chart shows that there is a substantial amount of crew time available for experimentation in the space station (after the prospective participants find the funding to get their experiments transported to the ISS).

Col. Collins answered a question about NASA's marketing efforts to advertise the availability of this program by citing outreach to the government, industrial, and academic sectors. Agreements are in place with various government agencies and other organizations to use the national lab. She observed that more potential exists and the committee would like to suggest that NASA continue its outreach, but look at non-traditional ways to reach out to some in industry who might be interested in using the space station but do not know the details of gaining access. It is hoped that the space station continues beyond 2016. To get additional funding, the experiments must display productivity and results—such as shown in the salmonella and staph experiments—the kind that would appeal to the public and generate scientific and practical results.

***Activities in the Next Quarter***

The committee will coordinate a trip with the Exploration Committee (during the third quarterly meeting) to the Ames Research Center. Goals are to learn about: the human/machine interface of Orion for both ISS and lunar missions; Orion water versus land landing; the Constellation Deep Space Operations beyond the moon; and Ames' work on handling qualities for moon/Mars landers. In addition, a few committee members will be attending the Aerospace Safety Panel briefing at the Johnson Space Center later in April. Col. Collins gave a quick summary of the committee's activities and showed a one-minute video that was taken last month from the STS-119 shuttle ISS fly-around. She shared a few facts about the space station: More than 171 people from 14 different countries and 77 spacecraft have visited the space station; there are six control centers in five different countries.

## Exploration Committee

Lieutenant General (ret.) James Abrahamson said that his committee has had a busy time since the last meeting. Much of the focus has been on the shift from design to test in the Exploration initiative. This included examining studies of reliability analyses to consider how the components are being validated and tested. General Abrahamson reported that he had visited the Aerospace Safety Advisory Panel (ASAP) and learned of its concerns and interests. Capt. Hauck talked to people at the Johnson Space center about LOC and LOM issues and how this potential loss is being calculated and worked into the design process.

***Status Report on the Formation of the new Exploration Subcommittee, Avionics, Software, and Cyber Security Subcommittee (ASCS)***

General Abrahamson gave a brief update on this new subcommittee. Dr. Alexander Levis, who was introduced at the last Advisory Council meeting, is serving as chairman. NASA has given excellent support to this subcommittee in quickly vetting the members, which has allowed it to move forward quickly. The terms of reference specify that the subcommittee will (1) focus its attention on the software and avionics systems being developed by NASA with a particular focus on the Constellation program; (2) review and assess NASA's approach, progress, vulnerabilities, and risk mitigation plans for its software and avionics system; and (3) assess the vulnerabilities of NASA's space flight systems and of the processes for their development and operations from a cyber security perspective.

ASCS will also review and assess NASA's approach to vulnerabilities and risk mitigation for all these kinds of systems. The membership of the subcommittee comprises a well-qualified technical team. The members are experienced in examining how agencies work on difficult problems. General Abrahamson stated that the members are clearly technical experts as opposed to policy specialists. The subcommittee held its first organizational meeting at the Johnson Space Center on March 24 to March 26 to set up a work plan for the first year. This subcommittee's work will be of interest to the Space Operations Committee and the Science Committee as well as others. Suggestions from the other Advisory Council members about priorities and scheduling are welcomed. Subcommittee members want to work closely with the Space Operations Committee as well as solicit ideas and tasking from other NAC committees.

Dr. John Sullivan commented that the Aeronautics Committee also examined verification and validation of software for aircraft. Dr. Sullivan noted that there would likely be considerable overlap in methods and techniques between mission critical software developed for aircraft and software developed for the Constellation Program. Primary flight systems are commanding a significant fraction of the cost of the entire aircraft with billions of dollars just on software and software verification. He said he was not talking about attack from the outside, but talking about errors in what was written. General Abrahamson asked that Dr. Sullivan share his ideas and input with the new subcommittee. Dr. Ford commented that obviously critical overlap existed in safety-critical software that used a lot of the same techniques.

***Human Ratings Requirements***

Capt. Hauck discussed the new Human Rating Requirements document. He visited the Johnson Space Center on March 4, 2009 for discussions with Carlos Noriega about Cx SR&QA. On April 15 the committee had a briefing by John Turner, Robert Cross, and Carlos Noriega who talked to the committee members about risk-informed design. In addition, a briefing not listed in the written presentation material was given by the new director of Constellation Systems Engineering and Integration, Laurie Hansen. Ms. Hansen was formerly the project manager for the Altair Descent Module and was asked to form and reorganize the systems engineering integration team in Houston.

NASA recently issued its new "Human Rating Requirement and Guidelines for Space Systems" (NPR 8705 2B), which is the baseline document that defines how design should take into account the threat to crew and mission and develop defenses against such losses, protecting the health and safety of humans involved in or exposed to space activities. The most striking difference in the rating requirements is captured in Paragraph 3.2.2. that redefines what should be the zero baseline for developing failure tolerance. The new requirement states, "Minimum of 1 failure tolerant to catastrophic events with the specific level of failure tolerance (1, 2, or more) derived from an integrated design and safety analysis." The previous requirement stated, "No two failures should result in crew or passenger fatality or permanent disability." The latter requirement was broad, requiring levels of redundancy and fault tolerance at the outset. It was the sense of the Constellation Program that, in using this approach, the vehicle could be "over designed." They postulated that by starting with a single-fault tolerant design, levels of fault tolerance would be added only if the perceived risk (using many different techniques including probabilistic risk analysis, hazard analysis, failure mode and effect analysis) warranted the addition of complexity, mass, and volume. Some believe that this approach could be more informative and educational and give a better understanding of the true risks facing any particular design.

Capt. Hauck said he felt that this is a bold, pioneering approach that treats risk as another design element from the very beginning. Dr. Gene Covert commented that he thought this was an excellent idea, but the risk analysis seems to be about highly unlikely events. He noted that the statistics of unlikely events are different from the statistics of normal distribution. He asked what approach they used in this risk-based design. Capt. Hauck replied that he didn't mean to imply that probabilistic risk assessment was the dominant approach. Other tried and true analyses help illuminate areas where risks need to be mitigated by design—and all those elements are incorporated. The big difference is that one is starting with a "cleaner sheet of paper" than the broad-brush, two-fault, failure-tolerant approach might have produced in the past. The risk-informed design approach has been influential in the design process only in the last year.

A participant commented that the shuttle was basically two-fault tolerant in most of its major systems and now one-fault tolerance is recommended as the standard approach. Due to the large mass of Orion, however, there cannot be all of the system redundancies that were built into the shuttle. For one-fault tolerance, for example, one would take care not to locate the two black boxes next to each other—if one box burns up, the other one might also. This is important work because when down to single-fault tolerance, constant, close attention to every detail is required. Capt. Hauck replied that once again he didn't want to imply that there will be less dual fault-tolerant systems. What the requirement says is that you have to "buy back" the risks that exist if an analysis concludes that we're not providing sufficient fault tolerance. It has to "argue itself in as opposed to being baseline from the beginning."

***Risk-Informed Design Process***

Capt. Hauck explained that the risk-informed design process generally follows a three-phase process. In phase one, a zero-based design (ZBD) is developed that is focused on key driving requirements. In phase two, once ZBD has been established, the focus is to make the design work and make it safe—with an emphasis on enhanced functionality and LOC risk. The design is evaluated to determine the best ways to mitigate risk. Methods might include adding a function (e.g., an abort capability), finding a diverse method for performing the critical function, increased testing to improve reliability, selecting more reliable components, adding margin to the system, or adding redundancy. Capt. Hauck noted that obviously it is also important to provide, when possible, geographic isolation for critical systems.

A major premise states that simple redundancy is one option to improve safety and reliability, but it is not always the safest or the most cost-effective option.

In phase 3, additional enhancements are considered, which more fully address functional requirements and which focus on reliability and loss of mission (LOM) results. The portfolio approach to comparing investments is used to increase the likelihood that the final design iteration produces a vehicle that safely and reliably (and within budget) meets the functional requirements.

To show the progress in the probability risk analysis, a chart was presented that indicated that of the three phases (formulation, preliminary design, and verification) NASA is currently in the preliminary design phase. Capt. Hauck noted that it is too early to go into the details of allocation of LOC and LOM numbers. A verification process will need to be accomplished as well as an independent peer review of verification models. Capt. Hauck said that it is hoped that the verification and testing process reveals those areas that the earlier process did not unearth.

The LOC LOM plan is to continue to refine a system model to reflect the latest preliminary design review (PDR) iterations for Orion and Ares. An update will reflect post LDAC-3 Altair design (LOM Buyback), which is an ongoing process. It is planned to integrate systems models into mission model and scenario analysis. A PDR fidelity analysis will be provided at the Program PDR LOC-LOM Achievability Assessment Decision Forum. Achievability of current LOC LOM requirements will be evaluated and additional mitigations or requirements for changes for action will be identified.

The Committee had a briefing from Ms. Lauri Hansen of the Constellation Program. She expressed concern about the limited amount of experienced systems-integration engineers. Capt. Hauck asked if she were bothered by the combination of dealing with the new way of addressing system design but at the same time having a shortage of experts in systems and engineering integration. Her response was that she actually felt that this approach to design forced more in-depth analysis and a better understanding of the integrated system than the old process.

***Operability***

Dr. John Logsdon said that the Exploration Committee members had a briefing on the concept of operability and how it is being applied to the Constellation program. NASA has created a Constellation Space Transportation Planning Office (in SOMD, not in ESMD). Edward Mango, the head of the office, who briefed the committee, is based at the Kennedy Center. The goal, after Orion and Ares are developed, is to make them as operable as possible. It is planned to have an 800 or 900-person constellation space transportation program (CSTP) office, once the systems get to the operational phase in 2015 or early 2016 under the current plan.

A displayed slide listed the definition of operability as "the system characteristics required to ensure safe flight while minimizing fixed and variable costs during the production, operating, and sustaining phases of the Constellation program." As Dr. Logsdon noted, "The point is to fly safely while minimizing costs of the program."

The Committee members thought it was almost past time with respect to the ISS mission for Orion and Ares, but they welcomed the information that operational considerations are being integrated with the program while is still in the design and development phase because, as Dr. Logsdon noted, "that didn't happen very much with the Shuttle which had many benefits but was not a very operable system."

Currently planning efforts are focused only on Constellation missions to the ISS. The Committee questions if, even at this very early stage, it might make sense to integrate some preliminary thinking about the Ares 1-Orion missions to earth orbit as part of the lunar scenario. It might be advantageous to begin to think how this might interact with Ares 5 in terms of the total lunar mission—and identify any actions that should be incorporated into the program at an early stage. The Committee intends to do more fact-finding before it is ready to offer any recommendations.

Col. Collins commented on the use of the term "operational" in one of the bullets on the chart that noted "the Shuttle became operational after its fourth flight." She said that the Shuttle truly never became operational and there seems to be two different definitions of the term. The Shuttle is not "operational" in the sense of an airline that flies every day. (The Columbia Accident Investigation Board stressed that.) This use of the term "operational" is on a different level—it is more of an experimental, operational level. Dr. Logsdon agreed, pointing out that in speaking of ISS missions, one is only talking about two flights a year. At the end of this decade, ISS missions—plus lunar—may be four ARES 1 and two Ares-5 missions a year. He said, "It's a different sort of thing. Atlas 5 and Delta 4 are termed operational and the goal is to get these systems to that point."

Dr. Eugene Covert observed that it was fair to say that the decision to call the space shuttle "operational" was made after four flights when the original goal was six flights. He said it was a political decision and everyone understood Col. Collins' point about that particular use of the term operational. The Shuttle was a flight test vehicle and the risks were reasonably high and, as Dr. Covert noted, "It was not like catching a bus on Constitution Avenue."

***Ad Hoc Biomedical Committee***

Dr. David Longnecker began by saying that that it had been helpful to the Committee to have the benefit of Capt. Hauck's personal flight experiences, which gave practical insights to the theoretical concerns

The Optimizing Science and Exploration Working Group (OSEWG) integrates science initiatives with mission planning to ensure the success of both groups. Originally, it was focused on "of the moon, on the moon, and from the moon"—but with the lunar orbiter, the concept of "near the moon" has been added. The group includes representatives from the various centers that are involved in science, including biomedical science and the Human Research Program (HRP) at JSC and the Office of the Chief Health and Medical Officer. OSEWG has prioritized the hazards for future flights.

Biomedical crew health and safety challenges for the lunar sorties are real but are thought to be manageable. Challenges for lunar habitation are greater for obvious reasons: longer exposure to partial gravity, more exposure to radiation, isolation, and other factors. The challenges for Mars missions are significantly greater than those for lunar exploration, due to both duration and distance from Earth. The greatest challenge in human exploration of Mars is radiation risk for extended flights.

Dr. Longnecker pointed out that the work of the integrating group is both necessary and appropriate, and the committee urges the group to continue its efforts. The Biomedical Committee would like to have periodic updates because the OSEWG activities are central to the research programs of the Science Mission Directorate, the Science Committee, and HRP.

NAC gave NASA 12 recommendations for lunar biomedical research pertaining to human research on the moon in 2007. An update on progress in implementing these recommendations was given by Dennis Grounds, who heads the human research program at KSC. The committee members saw significant progress in incorporating the general principles that the NAC recommendations had outlined.

Among these research activities is the Digital Astronaut Model—the modeling of various biological systems. Some of this work that is further along is in the areas of kidney stone formation, bone and muscle loss; some of the work that is earlier stages includes the cardiovascular system and the neuro-vestibular system.

OSEWG is continuing to work on the personalized medicine paradigm. The concept of personalized medicine is also known as P-4 medicine, which is predictive, preventive, personalized, and participatory.

This represents a fundamental change from the medical approach used in the past decades, which was populated-based medicine. The personalized approach deals with the individual rather than applying general remedies and prescriptions for all. This new concept needs to be promoted, which OSEWG is exploring further.

An exciting result of this committee, which began decades before, is the increased collaboration with NIH. Steven Katz contributed substantially to the progress of a signed memorandum of understanding (MOU) between NASA and NIH. In 2006, NIH and NAC had a workshop that began the process and in September 2007 an MOU was signed between Elias Zerhouni of NIH and Michael Griffin of NASA. [Note: This MOU stated that "the programmatic strengths of the NIH and NASA offer opportunities for synergy that can accelerate basic knowledge and technology development that can be applied to humans in space and on Earth."] Dr. Longnecker noted that progress had come to fruition with the public announcement that came out in March [entitled "Funding Opportunity Announcement: Biomedical Research on the ISS"]. In June there will be a meeting in Houston with an interactive phone session when investigators can call in to get information on applying for funding through the NIH mechanism.

Funding of projects will begin in FY 2010. The earliest time for ISS-based utilization will be in FY 2011. The Committee noted with satisfaction the potential for excellent experiments. As noted earlier, there is a funding issue about getting the payload up to the space station, but there are also approaches being used where potential investigators are being required to partner with organizations that can help lead to successful mission experiments.

The Biomedical Committee is very pleased that NASA and NIH will work together on research opportunities and feels that this collaboration can serve as a model for other governmental interagency cooperation.

## Aeronautics Committee

In the absence of General Lester Lyles, the Aeronautics Committee Chairman, Dr. John Sullivan served as the Acting Chair. Dr. Sullivan described the five briefings given to the committee. He began his presentation by explaining a chart that displayed a breakdown of the Recovery Act funding. NASA is receiving $1 billion from which Aeronautics will receive $150 million. The Congressional language specifies that the money will be spent on systems-level research development and demonstration activities related to aviation safety, environmental impact mitigation, and the Next Generation Air Transportation System (NextGen).

The Committee has been working on systems-level projects with the Aeronautics Research Mission Directorate (ARMD) for the past two years. In February 2008, NASA asked ARMD to look at possible systems-level, short-lived projects (4 to 5 years)—projects that would take some of the fundamental knowledge gained in the basic research program that could be applied to a systems-level integrated project. A year ago NASA asked ARMD to convene a workshop of experts from the aeronautics community to discuss this approach.

Dr. Sullivan said that the committee has been pleased with ARMD efforts in the fundamental research area, but that it is important to look at some of the new developments and do an integration of these at the system level.

In discussing some of the system-level projects envisioned for NASA aeronautics, Dr. Sullivan displayed a chart showing Environmentally Responsible Aviation (ERA). Another project is a supersonic business jet with a very long nose to mitigate the sonic boom over land. The jet would carry 10 passengers and

some of the aircraft companies had expressed interest in its development. But to be able to fly it, three conditions have to be met (1) it has to be able to fly over land with a supersonic boom low enough to change FAA regulations, (2) it must have low noise on takeoff similar to what we expect from all commercial aircraft, and (3) the economy has to improve. Another program being considered is uninhabited air vehicles and how to fly these in national air space.

To address validation and verification of complex systems, NASA is beginning to form two new programs under the NRA process. Fundamental research programs need to progress the first few levels of operation.

Dr. Sullivan noted that the Advisory Council had previously been briefed on the ERA program, which has two themes: the vehicle and operations. It is important to demonstrate the feasibility and benefits of the new vehicle concepts and technologies to mitigate the impact of aviation on the environment. This is something of great interest to the current administration and to the country.

Dr. Sullivan stated that the objectives of the system-level research program on Environmentally Responsible Aviation (ERA) are to:

1. Explore/demonstrate the feasibility, benefits, and risks of vehicle concepts and enabling technologies that have the potential to mitigate the impact of aviation on the environment.
2. Research system-level integration of key concepts that integrate surface, super-density, separation assurance and traffic flow management elements.

The ERA is a program that is examines what is referred to as N + 2 goals. These goals focus on next-generation concepts such as the open rotor and embedded engines to increase efficiency, reduce noise, and improve performance. The objective of ERA is to simultaneously reduce noise, emission, and fuel burn, thus improving propulsive and core efficiency and reducing the NOx.

Dr. Sullivan elaborated on a chart of Technology Maturation Perspective for the ERA program that defined levels of technology readiness levels (TRL) from levels 1 through 9. He explained that in product development there is a technology maturation level for a product ranging from the first level, observing and reporting the basic principles, up to the actual flight tests on level 9. Dr. Sullivan explained that typically the work at NASA in the fundamental research is going to fit in the TR levels of 1 to 3. But people involved in developing new products all know that there is a region in TR levels between 4 and 6 called the "valley of death" [component and breadboard validation in laboratory and relevant environments and system/subsystem model or prototype demonstration in relevant environment] that exists for new companies and also for projects within large companies. Achieving higher levels of technology maturation is one of the goals of this ERA—to get products ready so that industry officials are able to make decisions about whether they're going to use them. Dr. Sullivan observed that it is thus necessary to move some of this fundamental research "along a little further to show that integration is possible and that industry will have to decide where to take it from there." The idea is not to build prototypes for industry but to move the fundamental research to a level where industry can adapt it as needed.

In discussing alternate configuration concepts, Dr. Sullivan noted that there are many new ideas, but it has to be determined what combination of configuration and technology can meet the ERA goals and what development is possible in the N + 2 timeframe. Within the next six months, NASA will begin to select one of the many concepts to develop further. A slide illustrated some possible concepts such as embedded engines, putting the engines on the top of the wing instead of the bottom, and the blended wing body on which there are no windows with 20 people sitting across. The open rotor is a concept that was studied in the late 70s throughout the 80s. The studies showed that the open rotor configuration had a 5 to

8 percent improvement in efficiency (but with difficulties with noise and peoples' reactions to seeing the big blades rotating). Dr. Sullivan discussed many of the examples of innovative concepts being considered in the system-level research.

In the area of air traffic control, the North Texas Facility (NTX) is a metroplex (that includes two airports) where NASA research experiments can be carried out in cooperation with the FAA. The facility offers an operational environment where concept definition activities, support experiments, and systems analyses allow consideration of future aircraft fleets and operations. Dr. Sullivan said that some questions to be asked include how can we route the traffic better and use both facilities to the fullest—and this can be applied to other cities—and how do we use some of the underutilized airports and have them cooperate with the larger airport?

On May 14 and 15 a Meeting of Experts will be held at the Gaylord National Hotel and Convention Center at the National Harbor across from Washington, D.C. to discuss NASA's plans for system-level research in ERA. Expected participants include 25 subject matter experts, 5 NRC staff, 25 NASA presenters and participants, and 25 people from the general public. The proceedings will be available on a public website.

Amy Pritchett, the Director of NASA Aviation Safety Program, is organizing two new programs. One program, mandated by Congress, will be an independent review of NASA's safety-related research programs. The first proposed meeting will be held in June (three programs are in the budget). Committee membership is not yet finalized. A pre-press copy of the final report is due to NASA on February 15, 2010.

The other new program is the verification and validation of flight-critical systems. A core planning team is in place. This is a new program that is critical to all aviation and to space flight as well. One of the drivers for this was the decadal study, which stated that there should be a fundamental research program examining foundations for practical certifications standards for new technologies. There are large, software-intensive systems on an aircrafts. For instance, for certification of Flight Safety Level A programs, there are more than million lines of code, which means an expenditure of several billion dollars. Dr. Sullivan observed that this is a financially critical issue as "it is getting to the point where the applicable software costs more than the airframe."

Dr. Ford observed that at the heart of this issue are the costs associated with safety-critical systems and noted that this overlaps nicely with the activities of the Exploration Avionics, Software and Cybersecurity Subcommittee (ASCS). He said that NASA does not have a mature estimate yet, but that Constellation software will have millions of lines of code. This is a significant issue and one reason why the ASCS was formed. Those costs (and program risks) have not been fully appreciated." Dr. Sullivan agreed, saying that in product development now, software costs are underestimated—but these costs are a significant fraction (and can be as much as 50 percent) of the product's cost in many cases. He suggested that Amy Pritchett or someone on her team interact with the subcommittee.

***Mars EDL***

In introducing the subject of manned missions to Mars, Dr. Sullivan said that at the last Advisory Council meeting, there were discussions about entry, descent, and landing (EDL). NASA elevated EDL to the chief engineer's office a year ago because of the interaction of the various interested groups. ARMD held a meeting in March on the high-mass Mars entry system project underneath the fundamental aeronautics program.

Dr. Gene Covert began his presentation by saying that the entry, descent and landing problem is severe because presently there is no known way of doing it.

Dr. Covert described a ballistic co-efficient, which is the mass of the vehicle divided by its frontal area and the drag co-efficient. He said that if this number is more than 60 or 70, then one is dealing with numbers on the order of the Viking Program. He further explained that if you want to talk about the Mars lander and the MSL, it has a constant of about 140—a little less than a ton. To go up to the 20 tons required with the manned entry system, there is no technology that has been developed that will allow this. You can always say, "We'll make a rocket—and it will give us reverse thrust all the way down and give us a soft landing," But to do that, you have to launch about 400 tons—and NASA does not do 400-ton launches any more.

Dr. Covert said that the NASA Chief Engineer had concluded that no single mission directorate will be able to solve the EDL challenge alone. It is a cross mission directorate problem. It involves both aeronautics and space and it has been said that during entry and descent, aeronautics and space combined. Dr. Covert discussed a slide depicting EDL as an agency-level challenge. Eventual human Mars missions will require new EDL technology architectures for human-scale infrastructure and cannot be done in a vacuum.

The Mars EDL toolbox was developed for the Viking Program 40 years ago and served well at the time. NASA, however, now needs to develop an understanding of the requirements for future robotic and large-scale human mission set and develop EDL technologies that would serve both. Dr. Covert said the challenge needs to be approached from three different viewpoints. (1) We are much more ambitious now and the larger scale Mars EDL will need a cooperative approach among the three mission directorates; (2) Enabling human-scale missions to Mars requires extensive EDL architecture and technology efforts with a 25-year mission horizon if we start now; (3) If we are going to solve this problem, it is going to require coordinated, sustained investment for advanced EDL and atmospheric flight system technologies to reduce the mission risk for future robotic and human class missions.

Dr. Sullivan said during the last year the chief engineer's office started several programs analyzing system architecture. The programs are examining this low-fidelity modeling and asking what are the drivers for all of those? Under the various programs they are analyzing the details of the science needed to achieve success. It will take some time to formulate what is needed from the science community. They will have to devote some funding resources in reaching out to universities, to NASA, and to industry to develop the programs.

He discussed a slide, described in an earlier presentation, depicting an experiment performed on shuttle heat tiles during the re-entry of Discovery Flight STS-119. The image was taken with an IR camera on the Orion aircraft flying over the Gulf of Mexico, which Dr. Pat Condon had previously described. Data and the infrared imagery confirmed that the airflow was changed by a modified tile.

NASA researchers are continuing to analyze the data to understand the transition from smooth laminar airflow to turbulent flow. Dr. Sullivan noted there is still much to be learned about hypersonic transition. Preliminary reports indicated the maximum temperature experienced by the "protuberance tile" was around 2,000 degrees, somewhat less than expected. Dr. Sullivan noted some of the unknowns need to "get sorted out." NASA scientists still do not know enough about hypersonic transition or how to optimally design the thermal protection system for Orion. Dr. Sullivan remarked that a challenge for the designers was weight. He said, "We tend to over design these systems by a significant amount and we need to learn to do it better." It is hoped that this experiment leads to improved heat shield designs for the Orion spacecraft.

The Aeronautics Committee had no recommendations at this time. The environmentally responsible program is making good progress. At the next meeting, the committee will brief the Advisory Council on

the NASA ARMD Updated Plans for System-level Research in Environmentally Responsible Aviation and the results of the NRC Meeting of Experts. The committee will receive a briefing from the FAA on environmental efforts and connection with the ERA and a briefing from the ARMD Aeronautics Test Program.

## Audit and Finance Committee

Chairman Bob Hanisee reminded the group that at the last Advisory Council the 2008 audit was reviewed, which stated that NASA still had two material weaknesses: financial system analysis and oversight and accounting for legacy property. His Committee met with the auditors during this session. Mr. Hanisee had assumed that NASA would progress from a disclaimer—which is a statement from the auditor that the records are not sufficiently rigorous, traceable, auditable, and disciplined to do a full audit –and could progress from that disclaimer to a qualified audit opinion and eventually progress to an unqualified audit opinion. However, Ernst & Young informed the Committee members that the legacy assets continue to be an issue—and there is still no resolution on that problem.

***2008 Audit Remediation Update***

Mr. Hanisee reviewed some of the remediation efforts to address the problems identified in the 2008 audit. Resolution status has three categories: (1) partially remediated, (the scope of remediation has been identified and work is underway); (2) substantially remediated (NASA believes the deficiency has been remediated although more time may be needed to collect sufficient evidence to convince the auditors), and (3) fully remediated (the auditors have sufficient evidence that the deficiency has been remediated).

A displayed chart gave an account of the 2008 audit remediation update with the findings, the remediation activities, and the projected timeframe to complete the remediation activities. Chairman Hanisee discussed some of the actions taken on a few selected audit findings. The auditors found that the Continuous Monitoring Program (CMP) had inconsistencies in documentation and slow resolution of issues. The CFO's office has been working to resolve those issues and feels that this item will be substantially remediated this year and fully remediated in FY 10.

In the category on estimating environmental liabilities, NASA has audit findings that indicate that it is non compliant with Statement of Federal Financial Accounting Standards (SFFAS) 6, insufficient system controls as characterized by the Integrated Data Evaluation and Analysis Library (IDEAL), and the review processes for the environmental liability estimate were not functioning consistently. To address these issues, the Office of the Chief Financial Officer (OCFO) and Environmental Management Division are collaborating on a draft process for implementing SFFAS 6. They have also conducted a limited independent validation of the IDEAL models in use at JSC. The Unfunded Environmental Liability (UEL) Joint Review and Verification Form as well as other process documentation were updated. Mr. Hanisee noted that this UEL issue is only partially remediated this year and probably will remain partially remediated in FY 10 unless there is a "meeting of the minds, which we are working toward."

The topic of recording legacy asset values has had a great deal of discussion. NASA has been working with the Federal Accounting Standards Advisory Board (FASAB) to change the accounting for this issue to permit estimating as opposed to re-creating the actual documents. Unless there is a change in the financial accounting standard, NASA will remain partially remediated in FY 10.

The committee members had the opportunity to meet with the Ernst & Young auditors: Dan Murren, a Senior Audit Partner, and Eleanor Crawford, Executive Director, and two people from the Inspector General's (IG) Office, Evelyn Klemstine and Mark Jenson. NASA's IG, Robert Cobb, resigned several weeks ago and his deputy, Tom Howard, is the Acting IG at the present time. The Committee plans to

meet with Mr. Howard as quickly as possible. As noted at the last NAC meeting, Ernst & Young was rehired for another five years.

The audit plan was divided into four phases, each with specific implementation steps:

(1) Planning. This involves identifying significant financial processes that correlate with significant financial statement line items. A matrix showed all the processes with the significant accounts intersecting with them.

(2) Documenting internal controls. As part of this phase, site visits will be made to the Kennedy Space Center and to the NASA Shared Service Center at Stennis Space Center. An environmental liability walkthrough will be arranged at a site to be determined. A walkthrough of IT general and application control will be done at Marshall, two additional centers, and NSSC. There will be documentation of internal control processes as specified in OMB Circular A-123 (similar to SOX 404). The approach will also identify and explore the status of corrective actions.

(3) Determining if entity level controls are operating effectively—as designed. Steps to be performed include sampling (about 46 transactions across all centers) and testing entity level controls including submissions for CMP, FBWT, reconciliations, and budget execution.

(4) Reporting out to the agency. This involves reviewing elimination/adjusting entries; auditing financial statements and disclosure; obtaining legal and management responsibilities and issuing reports (audit of financial statements, internal controls, compliance with laws and regulations, and special purpose financial statements reporting.

In regard to accounting for legacy property and equipment, this issue is still not resolved. It is a frustrating area, but it is hoped that this difficult issue will be resolved if the FASAB Exposure Draft is accepted.

Historically, NASA did not have to capitalize its assets; it simply wrote them off as the money was expended. In 1998 a change in accounting standards required government agencies to begin capitalizing and depreciating this asset. This requirement began in 1998, and in the years 1998, 1999, 2000, 2001, and 2002 NASA received an unqualified audit opinion from its auditors, who at that time were PriceWaterhouseCoopers. NASA had one disclaimer in 2001 and in 2002 the external audit firm was changed to Ernst & Young. From 2003 to the present, NASA has had disclaimers in each year.

From the very beginning, NASA had a methodology for estimating asset costs and putting them on the books. The methodology was developed jointly with PriceWaterhouseCoopers and with Boeing, the contractor on the ISS. Apparently the methodology was adequate for previous auditors but not to the new auditors. Mr. Hanisee discussed a chart that shows the amount of legacy assets that remain to be depreciated on the ISS and the space shuttle. A total of 88 percent of all the booked asset values at NASA are related to these two programs. (The chart's WIP category refers to work in process that includes all the ground elements that have not been put into space yet. As they are put into space, the costs are moved to the shuttle or ISS categories.)The committee discussed whether the cost of a shuttle launch that brings components up to ISS should be capitalized. Some of the missions were mixed missions that brought resupply to the station as well as new components.

NASA's external auditors do not believe that NASA has the necessary supporting information available to provide auditable book values for the Space Shuttle and ISS. NASA disagrees with this assessment and believes that the auditors need to accept the approach and methodology being used for ISS and the Shuttle.

As Mr. Hanisee previously noted, there is an FASAB Exposure Draft that would permit agencies like NASA to use some very rigorous, disciplined, repeatable, auditable estimates of asset values if it did not have or could not recreate the historic costs. The OIG has taken the position that the costs of going back and recreating all those values would not be cost justified. The OIG asserts that it would be best to capitalize assets based on historical costs at the time of acquisition. If that is not feasible or cost-effective to do, then a reasonable estimation methodology should be acceptable to the external auditors and the IG. Ernst &Young agreed two days ago that it would accept this estimating methodology but it must be a rigorous, disciplined, repeatable, and auditable process. The agency has been creating the audit trail for these estimates.

NASA performed a robust review of the FASAB Exposure Draft, "Estimating the Historical Cost of General Property, Plant, and Equipment." It provided comments to FASAB noting that NASA supports the underlying intent of the document to provide a practical means for agencies to use estimates for existing Government PP&E for which capitalization was not originally contemplated, while protecting the underlying concepts in SFFAS 6 and 32. NASA will continue to await final technical guidance from FASAB regarding accounting for legacy assets, which is a government-wide issue. If the exposure draft is accepted, NASA can turn over these new values to Ernst and Young and hope that this will be sufficient to get past this issue. The committee hopes that by the next Advisory Council meeting it will know whether the exposure draft is being accepted. Mr. Hanisee noted that if the changed procedure is accepted, this "could break the log jam" for NASA in resolving this issue.

***PP&E Accounting—Identifying Capital Assets and Capturing Their Costs***

Mr. Howard Stanislawski next discussed new capital assets and how the agency could capture these new costs, as required by the new accounting system. The Committee was briefed about the processes being implemented for newly acquired capital assets. In FY 2008 NASA issued a NASA Interim Directive (NID) 9250, which established the procedural requirements for when PP&E purchase or fabrication meets the criteria for capitalization and how to separate the asset cost from other project costs for NASA's financial statements. To implement NID 9250, "Identifying Capital Assets and Capturing Their Costs," six entities play key roles: project manager, agency procurement, contractors, Agency OCFO, Center OCFO, and the Center Procurement Offices.

The procurement staff ensures that the types and approximate quantities of Government-furnished property and contractor-acquired property are discussed in procurement plans and procurement strategy meetings and that Center financial representatives are included in the procurement planning process. The procurement people have to fully discuss and evaluate with the relevant people in the agency and make sure that appropriate instructions, provisions, and contract clauses are included in solicitations and contracts and that everything is being done on a clear and consistent basis.

Contractors, as specified in their contracts, accumulate the cost for each item of NASA-defined capitalized PP&E, as required by NASA. They report current period costs incurred in acquiring or fabricating of individual capitalized PP&E as separate items on required reporting vehicles such as the NASA Form 533, the Contractor Cost Report. For fixed-price contracts, they itemize capitalized PP&E as a separate item on invoices or vouchers. They also make sure that contract reporting requirements are developed.

Even with the legacy asset problem being addressed and the implementation of the directive NID 9250, there are still problems associated with the PP&E issue. The first is that it does not apply to the major categories of capital assets such as the ISS and the Shuttle programs, which continue to represent the largest dollar amounts being expended for PP&E in FY 2008 through FY 2010. In addition, the procurement process has not yet determined what the new contractual provisions will be. The new policy

has not been fully disseminated and the new contract clause is still being developed. The new procedures will only apply to projects for which contracts were issued after October 1, 2007. This means that very large projects that had pre-existing contracts don't contain the obligation to implement this new procedure. To implement a new procedure in a pre-existing contract usually requires more money if the contract is to be changed.

***NASA Execution of the American Recovery and Reinvestment Act***

Mr. Stanislawski discussed the briefings his committee received on the American Recovery and Reinvestment Act. He explained that the Act's key purposes were to "preserve and create jobs and promote economic recovery" and "to provide investments needed...by spurring technological advances in science..." NASA will receive $1 billion, broken down into $400 million each for science and for exploration; $150 million for aeronautics; $50 million for CAS (to rebuild the Jackson Space center hit by Katrina); and $2 million for the Office of the Inspector General.

This money is a one-time commitment by Congress and the Administration. Most of the money is two-year funding and "then it goes away." It will be a challenge for any agency that receives stimulus money of this kind to integrate the funds into its budgetary process and to use the money efficiently on specific projects. The projects will end—and it is vital that the agency has the proper internal capabilities to manage the funds and not acquire new obligations that the agency cannot continue to meet.

The money is to be used for programmatic purposes utilizing existing NASA resources and capabilities. There is a high level of awareness in the agency of the need for transparency, required by the statute. Separate accounts will be maintained to track the funds. If the funds are used, the money will be subject to normal requirements. That information can be found on the website: www.recovery.gov.

To the maximum extent possible, contracts should be awarded as fixed-price contracts through competitive procedures. (Special posting requirements apply if the contracts are not fixed price.) Mr. Stanislawski commented that over the years the government "has gone back and forth on what sort of contracts should be required. It's pretty well understood that research and development does not operate well in a fixed-price environment.

The Act stipulates the usual "Buy American" requirement—use of American, iron, steel, and manufactured goods, with limited exceptions--which NASA has never had difficulty meeting. The Act requires the establishment of a Recovery Accountability and Transparency Board, which will coordinate and conduct oversight of spending under the Act to prevent fraud, waste, and abuse.

***Quality Assurance Division (QAD)***

Mr. Michael Montelongo stated that three major hurdles remain to be overcome: (1) financial processes and having good internal controls; (2) PP&E accounting, and (3) unfunded liabilities. He stressed the significant progress already made in addressing the necessary internal financial processes—and the solid work accomplished in the internal controls area. He said that the CFO and team have made great strides in either revitalizing or instituting the necessary infrastructure to address the problems in the financial process area. NASA can take great pride in the significant progress made in instilling the rigor and discipline necessary for good financial management.

The areas of PP&E and the area of unfunded liabilities remain problematic. The Quality Assurance Division (QAD) has been instrumental in revitalizing the financial infrastructure. This is the key implementation arm for the CFO's Comprehensive Compliance Strategy (CSS). QAD was established in 2008 to "set the tone at the top" to instill the necessary discipline and rigor into enterprise audit and financial reporting processes. Mr. Montelongo added that it was chartered, in his opinion, to help the CFO organization "do the right things right."

The Committee supports the continuous monitoring program that assesses, coordinates, and addresses accounting and financial management internal controls and ensures compliance with General Accepted Accounting Principles. Its primary functions are checking and remediation, proactive auditing, and testing as well as consultation and training. A slide listed QAD's primary activities: financial statement readiness; financial statement internal control testing; financial statement property audit; unfunded environmental liabilities; Improper Payment Improvement Act; A-123 audit; and evaluation, monitoring, and testing.

In going forward, the "Big Four" focus areas will be on (1) property valuation; (2) financial statement preparation; unfunded environmental liabilities, and intergovernmental reconciliation.

***Unfunded Environmental Liabilities FY09 Audit Remediation***
The key issues are NASA's methodology for estimating liabilities using a model borrowed from the Navy, called IDEAL; adherence to SFFAS 6 (which requires estimates of liabilities when an asset reaches its useful life), and remediation of asbestos across NASA's facilities.

The progress to date includes the CFO and the Environmental Management Division agreeing to partner and form a Joint Review Team. This team has reviewed 49 remediation projects at 9 sites and has completed 4 onsite validations of IDEAL estimations. Consensus with the external auditor on SFFAS 6 interpretation remains to be accomplished. It is proposed that asbestos remediation be pushed beyond FY2010.

***NASA Continuous Monitoring Program***
Mr. Ted McPherson described NASA's Continuous Monitoring Program as a detailed transaction accounting control process led by Leslie Hyland, Director of the Financial Management Division of the Office of the Chief Financial Officer, across all NASA Centers. This process is meant to correct the root causes of errors in financial data for major line items such as fund balance with treasury accounts, accounts receivable, accounts payable, status of funds etc. The issue of finding the causes of errors is addressed in working session called clinics in which accountants, analysts, and subject matter experts reach closure on solutions, execute corrections, and compile instructional documents used widely in staff training. Mr. McPherson noted that valuable results have been achieved as a result of this work.

He presented a slide that showed a dramatic reduction in incorrect accounting entries (in millions of dollars). The chart compared March 2008 to February 2009. For the category of fund balance with Treasury, the amount of dollars not correctly accounted for has been reduced from $9.7 million to $1.5 million; in accounts receivable, the numbers went from $3 million to $.2 million. Accounts payable was reduced from $91.4 million to $.8 million; purchase orders were fully corrected from the starting point of $59.4 million, and blank and mismatched entries were reduced from $666.1 to $ 30,000. The total number from all accounts (excluding property) was a reduction from $872 million in March 2008 to $5.3 million by February 2008, which is a remarkable accomplishment.

Mr. McPherson said that he presented the next chart to "illustrate the folly of this property accounting." In March 2008, the amount of incorrect entries was $751 million and that number grew in September 2008 to more than $11 billion dollars and now in February 2009 it has come down to $4 billion . He said that in examining these numbers, one can see the instability of property accounting the way NASA is currently approaching it. Mr. McPherson said that was why the Committee was relentless in "resolving this issue because it really lacks some common sense and doesn't deliver a whole lot of value in the way it is being done."

In response to Dr. Ford's question about the cause of this instability, Mr. McPherson said that the methodology being used by the IG and the external auditors "looks at a micro level of detail at parts and pieces instead of looking at the whole thing." He offered the analogy of baking a cake—and tracking accounting for the individual costs of sugar, milk, grains of flour, in great detail instead of saying "What's the cake worth?" and booking a reasonable estimate of the cake's value. He said other agencies have ways of correcting this and NASA needs to find a way too. USDA staff dealt with $10 billion worth of property and found ways to account for it in a constructive, accurate way using estimates and went from a disclaimer to a clean opinion in 1 year.

***Other Issues/Update***

In discussing accounting transaction processing at the NASA Shared Services Center, Mr. McPherson said that in the future the Center will have high-unit costs due to the $50 million initial investment and low transaction volumes. Further improvement is needed in the timeliness of accounts payable (to avoid late-payment interest charges) and to smooth out the single-grant accounting process. Other updates include:

- The OCFO currently has 96 staff members and seven vacancies and uses 29 contractors. Two chief financial officer vacancies are in the process of being filled at Goddard and Dryden (two acting officers currently fill the slots).
- NASA currently has 8,000 active grants with approximately 1,000 institutions –a total of $ 7 billion. NASA centers have changed from using a bundled approach to performing single grant-by-grant accounting except for Goddard, which is in the process of making that change.
- Attendance at scientific and technical conferences does not have a limitation imposed by the FY 2009 Appropriation. Attendance, however, is still included in the reporting requirement.

Ms. Nancy Abell, the Acting Chief Financial Officer and Associate Center Director at the Goddard Space Center, briefed the Committee. Goddard currently has 97 full-time, equivalent staff performing, accounting, and transaction processing work for NASA headquarters, Jet Propulsion Labs Management Office, and Goddard Space Flight Center. They have had accounting issues that required improvement. In the 2008 audit, Ernst &Young issued eight findings related to Goddard, which will be corrected by the end of this month. PriceWaterhouseCoopers, in its review of internal controls, issued six exceptions, which will also be corrected by the end of this month.

Mr. McPherson said that much work needs to be done to get Goddard into a single grants process rather than bundles by September 2009. A current primary focus is converting and reconciling 5,000 active grants to 430 institutions to single grants rather than bundles, which the Committee feels Goddard will do by September 2009.

Mr. McPherson concluded his presentation by sharing the committee's near-term future focus, which will concentrate on finding a solution for the property, plant, and equipment accounting. Members feel that it is important to brief the new NASA Administrator (when appointed) on the importance, progress, and current opportunities for continued improvement in these accounting areas.

In response to a question about whether other agencies had similar experiences dealing with financial accountability, Mr. Hanisee said some of the committee members possessed extensive experience with other agencies. The USDA dealt with a lot of these same problems and was able to get a fresh start on PP&E—it was able to write off the old equipment. Mr. Ted McPherson said that in 2001 there were 24 Federal agencies audited and at that time only one or two received a clean audit. At the end of 2008, there were only four that had not received a clean opinion - including DoD and NASA.

In contrast to three years ago, when the audit committee was formed, there is now a very small number of intractable accounting issues, several of which could be solved with the application of some common sense. Michael Montelongo was in the office of the Secretary of the U.S. Air Force, which had the same challenges. He explained that it was not surprising that DoD, like NASA, would have these kinds of challenges with PP&E and unfunded liabilities because of the kinds of military activities, its research and development and its massive amount of equipment. It is, however, unusual to take this amount of time to resolve the issues, as in NASA's case. Dr. Ford pointed out that NASA formerly had clean audits until changing auditors. He emphasized that it was not the case that the agency has not had clean audits. He said, "We now have these problems that are intractable with respect in getting an interpretation from the external auditor or IG that would allow the agency to address these problems."

One of the Committee's frustrations is that NASA has made enormous progress in the past three years and there is no comparison between where the agency is today in terms of financial accountability compared to three years ago when the audit committee was formed. Mr. Hanisse noted that Headquarters CFO Ron Spoehel has made "great progress" in the Continuous Monitoring Program and gradually all the centers are now aligned with this one NASA concept so that they are all working toward the same objective. Despite all of this progress, it does not show in the result because of the legacy PP&E problem.

## Closing Remarks:

Dr. Ford commended the Audit and Finance Committee for its remarkable work and for being so deeply engaged. He thanked the NAC Executive Director and all the Council members for their participation and commitment to provide constructive feedback. Six recommendations were proposed and discussed. Dr. Ford asked that Dr. Kennel and Dr. Longnecker work with Dr. Kulcinski to incorporate their comments into the recommendation on workforce that the Human Capital Committee presented. While there may be some refinement of the recommendations presented to incorporate the discussions of the Council, Dr. Ford anticipates that all will be submitted to NASA.

Dr. Ford announced that the council's next meeting will be in July at NASA Ames Research Center. The re-designed NAC website, www.nasa.gov/nac, will have the details of the next meeting as well as the presentations from this meeting.

After receiving no comments from the public, Dr. Ford adjourned the meeting.

| | **NAC Plenary Public Session**<br>**Thursday, April 16, 2009** |
|---|---|
| Chair | • **Dr. Kenneth Ford**, Founder and Director, Florida Institute for Human & Machine Cognition |
| Aeronautics Committee | • **Acting Chair: Dr. John Sullivan**, Professor of Aeronautics and Astronautics Director of the Center for Advanced Manufacturing, Purdue University<br>• **Dr. Eugene E. Covert**, T. Wilson Professor of Aeronautics, Emeritus, Department of Aeronautics and Astronautics, Massachusetts Institute of Technology |
| Audit and Finance Committee | • **Chair: Mr. Robert M. Hanisee**, Trust Company of the West<br>• **Hon. Edward R. "Ted" McPherson**, Chief Executive, Intersolve Group,<br>• **Hon. Michael Montelongo**, Senior Vice President, Strategic Marketing, Sodexho Inc.<br>• **Mr. Howard J. Stanislawski**, Partner, Sidley Austin, LLP |
| Exploration Committee | • **Chair: Lieutenant General James A. Abrahamson**, USAF (Ret.)<br>• **Hon. Donald Fraser**, Draper Laboratory (Ret.)<br>• **Capt. Rick Hauck**, USN (Ret.)<br>• **Dr. Stephen I. Katz**, M.D., Ph.D., Director, National Institute of Arthritis and Musculoskeletal and Skin Diseases<br>• **Dr. Alexander H. Levis**, Professor, Head of the System Architectures Laboratory, Volgenau School of Information Technology and Engineering, George Mason University<br>• **Dr. John M. Logsdon**, Charles A. Lindbergh Chair, Aerospace History, National Air & Space Museum Smithsonian Institution<br>• **Dr. David Longnecker**, Institute of Medicine, National Research Council |
| Human Capital Committee | • **Chair: Dr. Gerald L. Kulcinski**, Associate Dean of Research, College of Engineering, University of Wisconsin-Madison<br>• **Dr. Lucy Fortson**, Vice President for Research at the Adler Planetarium and Astronomy Museum, Chicago<br>• **Dr. Ioannis Miaoulis**, President and Director of the Museum of Science, Boston |
| Science Committee | • **Chair: Dr. Jack Burns**, Professor, Department of Astrophysical and Planetary Sciences, University of Colorado and Vice President Emeritus for Academic Affairs & Research University of Colorado System<br>• **Dr. Bradley L. Jolliff**, Research Associate Professor, Department of Earth and Planetary Sciences, Washington University<br>• **Dr. Mark S. Robinson**, Research Associate Professor, Department of Geological Sciences, Arizona State University<br>• **Dr. Michael Turner**, Bruce V. and Diana M. Rauner Distinguished Service Professor, The University of Chicago |
| Space Operations Committee | • **Chair: Col. Eileen Collins**, Astronaut (ret.)<br>• **Dr. Pat Condon**, Aerospace Consultant<br>• **Dr. Owen Garriott**, Astronaut (ret.)<br>• **Mr. Jay H. Greene**, Consultant, Aerospace Engineer<br>• **Dr. Thomas Jones**, Astronaut (ret.)<br>• **Adm. Benjamin Montoya**, CEO, SmartSystems Technologies |
| *Ex-Officio* | • **Dr. Charles Kennel**, Chair, Space Studies Board, National Research Council |
| *Not Attending* | • **Dr. Raymond S. Colladay**, Chair, Aeronautics and Space Engineering Board, National Research Council<br>• **Dr. Ilan Kroo**, Professor, Professor of Aeronautics and Astronautics, Stanford University<br>• **General Lester L. Lyles**, USAF (Ret.), Consultant, The Lyles Group<br>• **Dr. R. James Milgram**, Professor, Department of Mathematics, Stanford University<br>• **Dr. Byron Tapley**, Director, Center for Space Research Professor, Aerospace Engineering, University of Texas, Austin |

## Attendees and Affiliation

| | |
|---|---|
| Jon Maloy | Lockheed Martin Corporation |
| Cheryl Reed | JHU/APL |
| Jane Parham | NASA ESMD |
| Linda Karanian | LMC |
| Susan Wirth | ITT |
| Tracy Lamm | PWR |
| Russ Bardos | Aerojet |
| Peter Sidle | Consultant |
| Kelly Barnes | QAD |
| Lori Meikle | QAD |
| Charles Elachi | JPL |
| Bridget Glynn | Lewis Burke |
| T. Jens Feeley | NASA SMD |
| Rebecca Kasir | NASA SMD |
| J.D. Reeves | PP&E/SID |
| Frank Peterson | NASA OCFO |
| Kim Terrell | KIMS LLC |
| Julie Robinson | NASA ISS |